Electricity Market Design | 6 October 2022

# 9th Annual EPRI-IEA Challenges in Decarbonization Workshop

## A window into the global energy transition

Session 2: Electricity market design for high renewable systems

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# Need for the evolution of power markets

*To support the energy transition towards net zero carbon systems*

## Power market design is an important tool that can't be considered in isolation

- Clean and alternative fuel incentives and feed in tariffs
- Carbon pricing mechanisms
- Cross sector coupling
- Consumer protection

## Requirements for successful competitive power markets

- Incentivize performance (system, plant level) and needed characteristics
- Adequately pay for needed longer-term plant investments
- Ensure reliability, stability and resilience and drive system efficiencies

Remuneration mechanisms to promote resource investment and operational signals for the energy transition

# Electric power systems operated to least cost

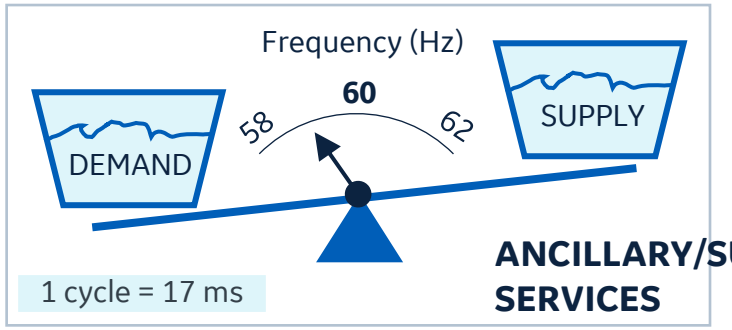
*Economics and location of physical assets drive operations*

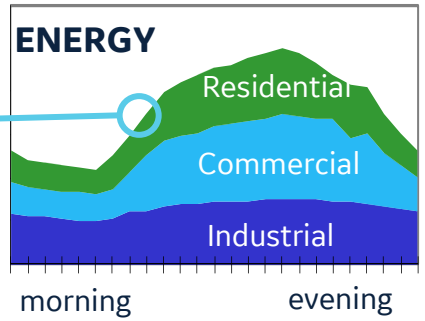
**PHYSICS**

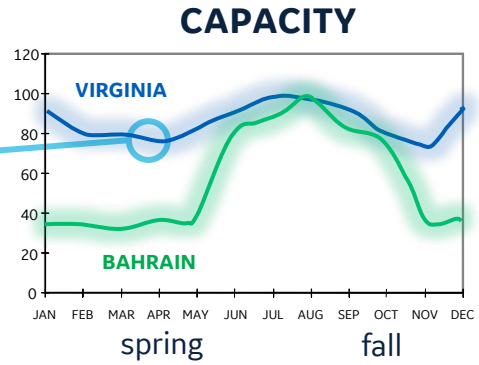
*... maintain frequency and voltage*

**BALANCING**

*... deliver enough power to meet demand*




inertia

governor resp

regulation

real time/balancing

day ahead

capacity

Machine controls

Grid operator controlled

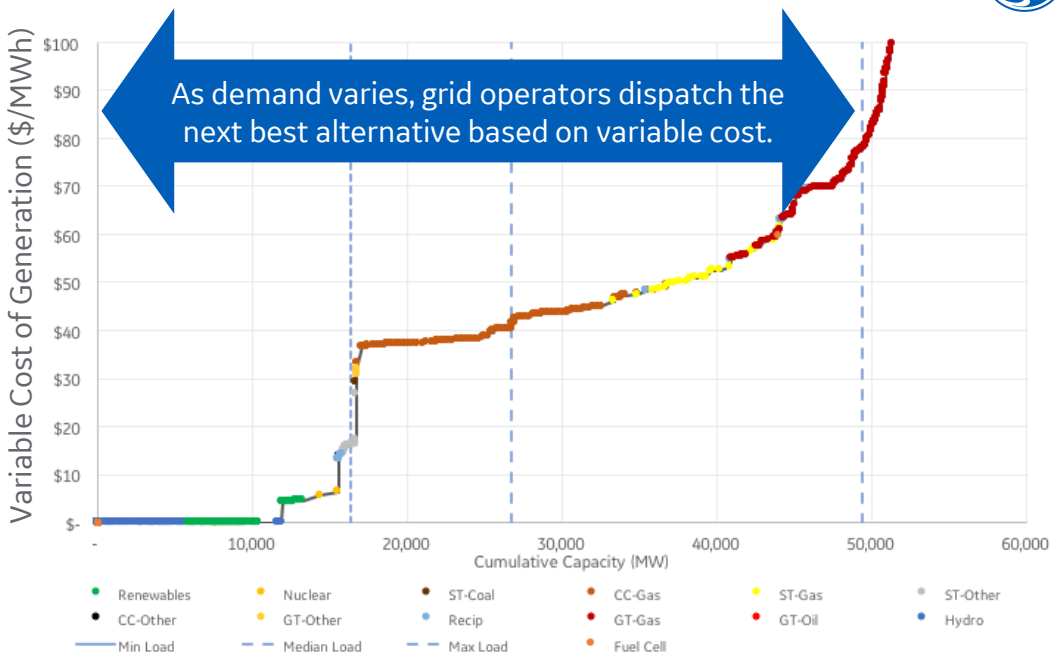
SECONDS ← HOURS → YEARS

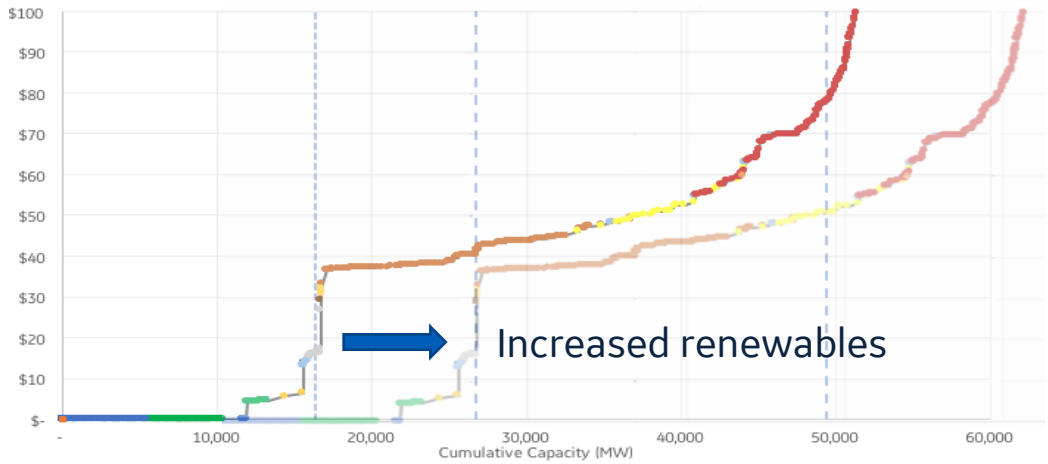
**Stability** **Energy Deliverability** **Adequacy**

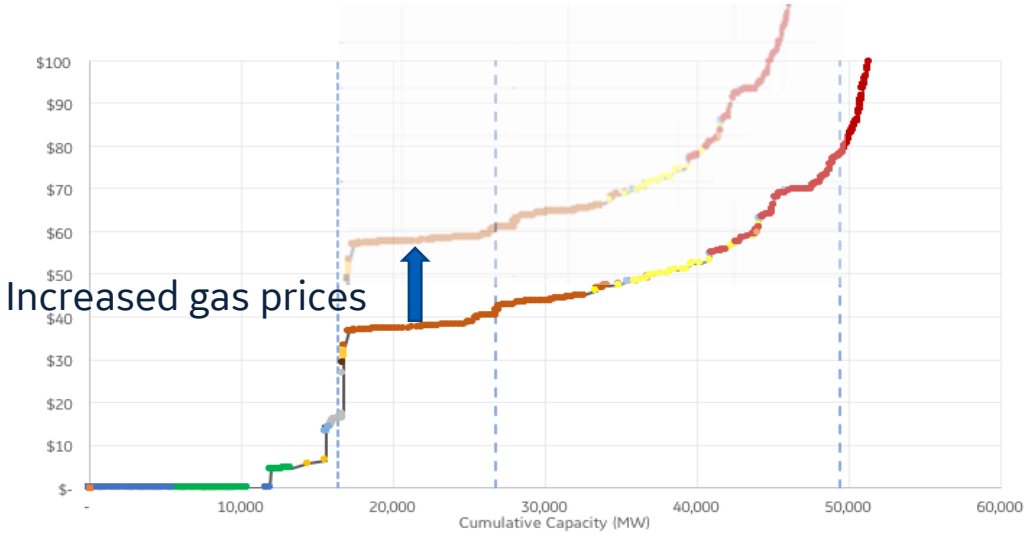
# Energy price mechanisms

## Marginal energy prices pay as clear, reflecting least cost of efficient operation

- Promote market liquidity and price transparency
- Provide for creation of hedging instruments
- Price foundation for PPAs and CfDs
- Reflect externalities i.e., carbon pricing



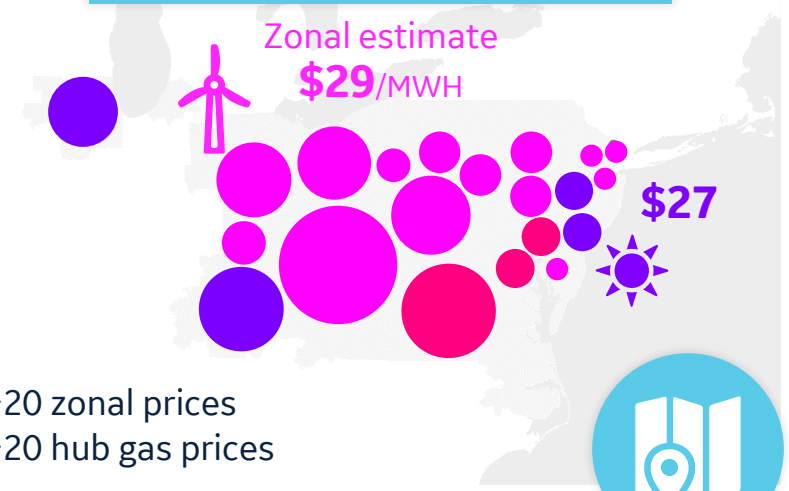



# Locational marginal prices (LMP)

## *Reflect security constrained dispatch*

**ZONAL**
*Lower resolution*



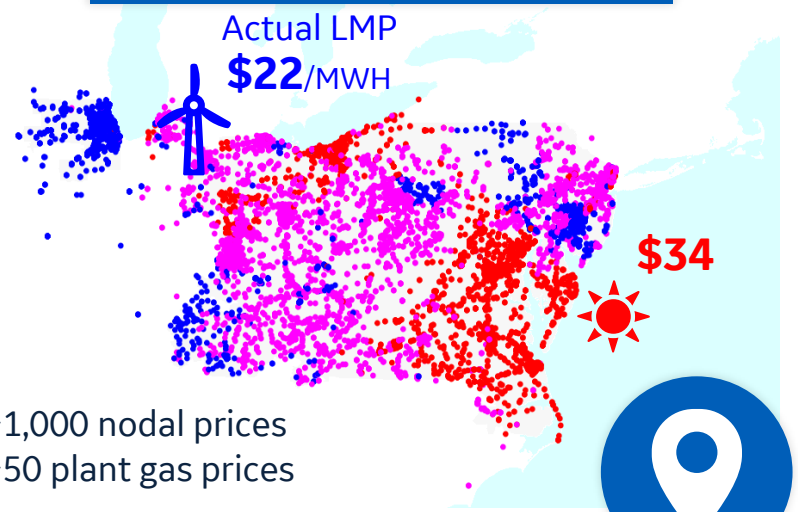

~20 zonal prices
~20 hub gas prices

**~200 MB**

**ZONAL** price scenarios

- Inter-zone constraints
- Timescale groups
- Lower computational need, less data intensive
- Less reflective of locational oversupply and scarcity pricing

**NODAL**
*Higher resolution*




~1,000 nodal prices
~50 plant gas prices

**~2 TB** Typical 20 yr. simulation (PJM, Eastern interconnection)

**NODAL** price scenarios

- Full transmission constraints
- Timescale granularity
- High computational need
- Location of oversupply and scarcity
- Signals for location of new generation, transmission (& demand) investments

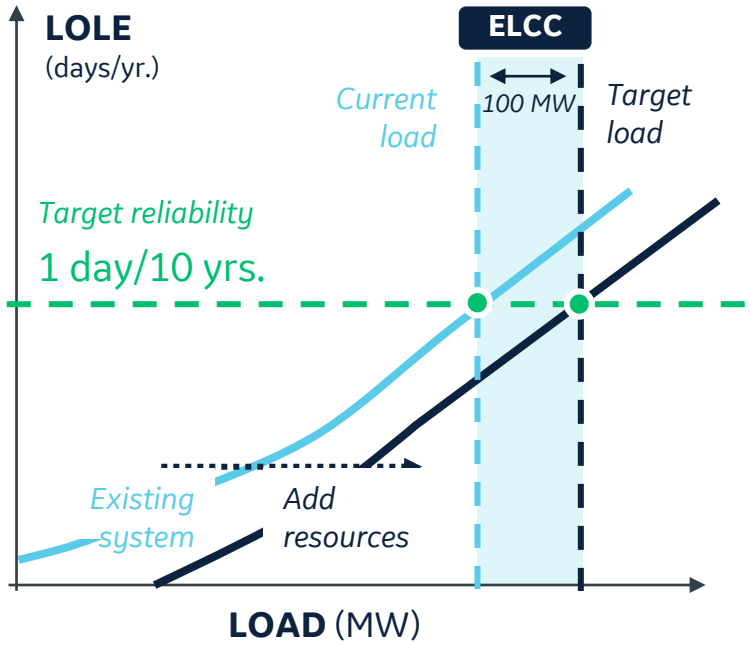
Ref: Hitachi ABB Ventyx
e.g., PJM, '17 annual average prices

# Capacity price mechanisms

## Pay for demonstrated, dependable capacity:

- Ensure resource adequacy
- Provide forward prices (years) for long-term investment, supply “missing money”
- Technology agnostic, and may reflect specific essential reliability support services i.e., ramping

Dependable capacity can be assessed as Effective Load Carrying Capacity (ELCC) as VREs increase

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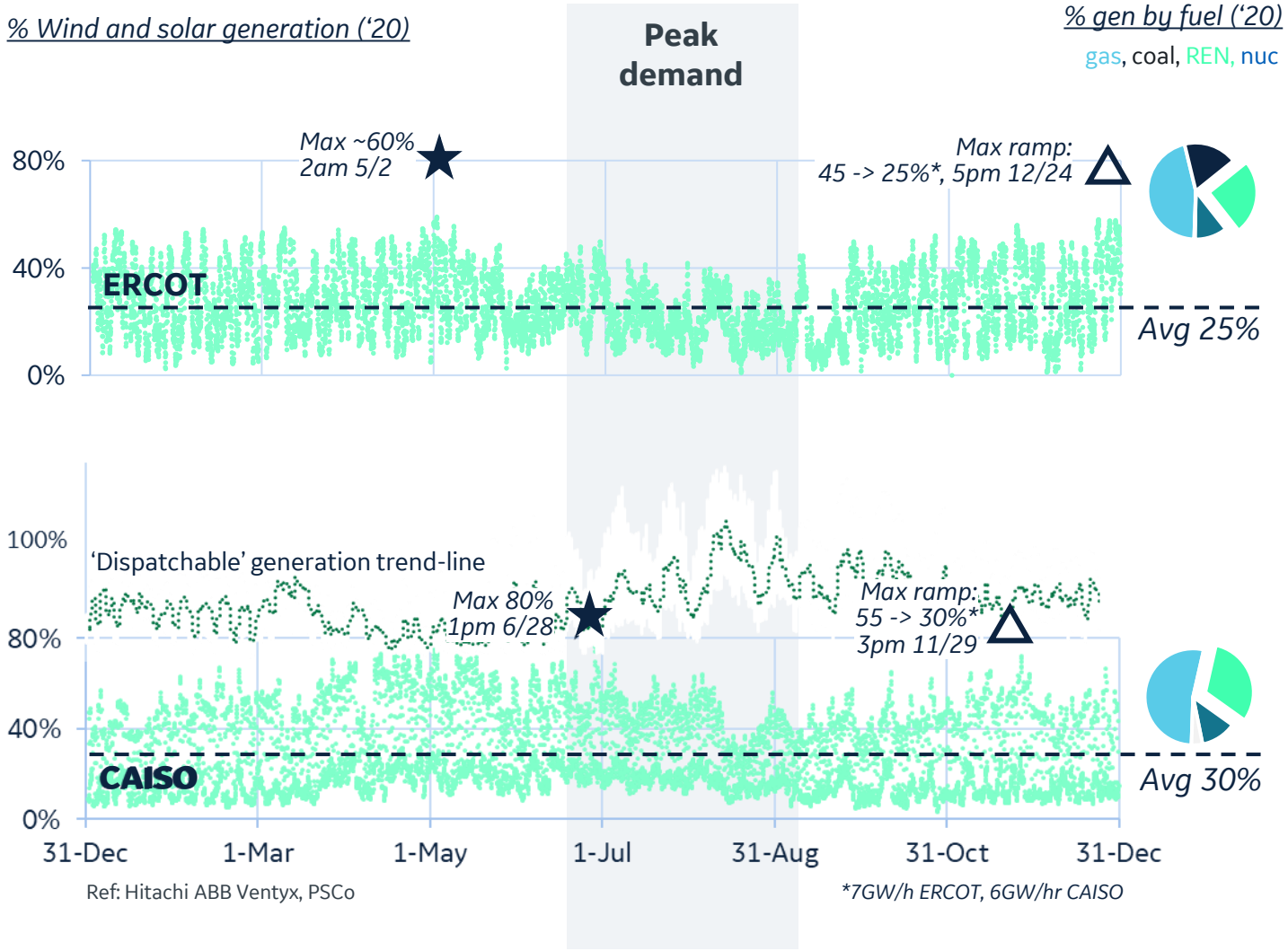
*Challenge: No one-size-fits all … Existing system matters*

# Serving net load with high penetrations of renewables

## *Traditional ancillary services must be expanded*




## Essential reliability support services

Variable renewable energy (VREs), namely inverter-based resources don't provide the same system services as rotating equipment

- Operating Reserves: primary, secondary, tertiary (frequency response, spinning reserves and supplemental reserves)
- Fast frequency response products
- Ramping products
- Reactive power & dynamic voltage support
- Inertial response
- Black start and restoration

# Power market design to support the energy transition

*Ensure reliability, stability and resilience and drive system efficiencies*

- Incentivize performance at both the system and plant level
- Incentivize needed plant characteristics to provide additional support services: fast ramping, fast frequency response, etc.
- Pay for needed plant investments to ensure longer-term system adequacy
- Promote cross sector coupling, T&D expansion, distributed energy resources and active demand-side management with prosumer participation and consumer protection

Building a world that works